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STEAM HEATING OF AIR FOR TEA DRYING MACHINES*

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Since the writer published an article in *The Tea Quarterly* under the heading "The Use of Steam in Tea Factories," Volume VIII Part III, November, 1935, pages 147 to 151, he has been responsible for the installation of the "all-steam" system of operation in seven tea factories in North-East India where there are now a total of 27 dryers working on the steam-heating system, and the results obtained are of sufficient interest and importance to the Ceylon Tea Industry to warrant a further article.

Many readers of this article will have seen the small steam-heated dryer used for experimental work in St. Coombs Factory, and will have appreciated the cleanliness and ease of control. That installation works on live steam, whereas the large scale commercial plants work mainly on low pressure steam at from 5 lbs. to 7 lbs. (gauge) pressure exhausted from a steam engine, which provides the power for driving the factory.

The steam is used in suitable radiators to heat the air for the dryers, and does not come into direct contact with the leaf.

Low pressure steam alone is sufficient for drying temperatures of up to 200°F. but above this temperature it is necessary to arrange to work the last section of the radiators on steam at boiler pressure, usually 120 lbs. gauge.

This system can be used with advantage anywhere in the world even if the water available for the boiler is scarce and of poor quality, as once the boiler has been filled the same water is continually recirculated and the boiler therefore works under almost ideal conditions with distilled water, as the quantity of fresh water required is only that needed to compensate for any loss by leakage which should be a very small amount.

* The Institute does not necessarily endorse the views expressed in papers contributed by others than members of the staff.

The first factory in which steam-heating of air for the tea dryers was tried out, using mainly exhaust steam from the steam power plant, was partially converted to this system in 1937 and very quickly showed that the scheme was simple to operate, thoroughly reliable and highly economical. The simplicity of operation is specially emphasised because it not infrequently happens that increased fuel economy can only be obtained by increased complication and, in such cases, some of the saving in fuel is offset by a need for more expensive supervision, whereas, with the steam-heated dryers, the system is extremely simple and the drying temperature is maintained constant within very close limits.

The existing drying equipment in this first factory to be converted consisted of a 6 ft. "Empire," two "Paragon," and three "Down Draft" dryers, and it was decided, in the first instance, to try out the scheme by converting the 6 ft. "Empire," and one of the "Paragon" dryers, to the steam heating. About two-thirds of the crop could be handled by these two dryers alone, using the "Empire" for first firing and the "Paragon" for second firing. The total coal used for power and drying for the previous season, 1936, had been 2.06 lbs. of coal per lb. of tea and, by using steam heating for two-thirds of the crop, the total coal for power and drying was reduced to 1.4 lbs. of coal per lb. of tea on a crop of 954,400 lbs.

For the 1938 season, it was decided to convert the second "Paragon," this enabled about seven-eighths of the crop to be handled by the Steam-Heated dryers leaving the three "Down Draft" dryers unconverted, for use on very heavy "rush" days. This factory has now been worked in this manner for two seasons, 1938 and 1939, and the total fuel consumption was reduced to 1.07 lbs. of coal per lb. of tea for power and drying on a crop of 1,028,800 lbs. in 1938 and 1,009,440 lbs. in 1939.

Very careful watch was kept on the quality of the tea, and it was the unanimous opinion of all concerned that the effect of steam heating had been towards improving the quality, as was only to be expected, by reason of the constant drying temperature. It is also very satisfactory to be able to record that the original equipment has now worked for three seasons with no expenditure whatever on maintenance of the steam-heating plant.

The Steam Heating system having proved so very simple, reliable, and economical in operation, it was decided by the same Managing Agents to convert fully three other factories to this system, and another managing agency converted one factory of a group in Upper Assam to the "All Steam" system of operation for the

1939 season, so that, during that season, there was at least one factory in each of the main districts — Assam, Dooars, Sylhet and Cachar — fully converted to the new system, comprising a total of twenty steam heated dryers of various makes, types, and sizes, and a further seven dryers were converted to steam heating for the 1940 season, making seven factories in all working on the "All Steam" system.

The very remarkable results achieved during 1939 are now available, and by the courtesy of the Managing Agents concerned, are presented herewith.

Table showing amount of coal used with the "All Steam" system for power and drying, as compared with drying only.

District	Drying only. Average 1936/7/8.			Power and Drying "All Steam" System 1939.	
	Number of Gardens	Total crop lbs.	Lbs. of coal per lb. of tea Drying only	Crop lbs.	Lbs. of coal per lb. of tea Power and Drying
Assam	24	8,484,800	1.2	Garden A 1,003,840	1.27
Dooars	11	6,452,400	1.29	Garden B 1,053,520	1.65
Sylhet	15	7,632,240	1.05	Garden C 1,009,440	1.07
Cachar	5	1,196,160	1.6	Garden D 538,000	1.39

Table showing saving actually realised by the "All Steam" system of operation.

District	Crop made lbs.	Saving in lbs. of coal per lb. of tea.	Remarks
Assam	Garden A 1,003,840	(.5) See footnote *	Previously used :—Old engine for power and coal for drying.
Dooars	Garden B 1,053,520	.61	Previously used :—Separate coal fired steam plant for power and coal for drying.
Sylhet	Garden C 1,009,440	.94	do do Has now worked for 3 seasons.
Cachar	Garden D 538,000	(1.14) See footnote.*	Previously used : - Oil engine for power and oil fuel for drying.

* For the purpose of providing a satisfactory basis of comparison a figure is shown in brackets representing in terms of coal the total saving in fuel actually realised on the Estates concerned, *e.g.*, a total saving of 0.94 cent per lb. of tea, with coal costing 0.78 cent per lb. delivered on the Estate, would be represented by 1.2 lbs. of coal per lb. of tea.

The savings indicated in the preceding tables are exclusive of any allowance for elimination of stove, and chimney renewals.

In the first table figures are given for fuel consumption for drying only for 1936, 1937 and 1938, representing the average of a stated number of estates in each district and it will be seen that, with the "All Steam" system, the fuel required for power and drying is only very slightly in excess of the amount required for drying only in the normal manner.

On some estates, particularly in the Dooars, a certain amount of wood has been used in the dryers and, in such cases, any wood used has been converted to a "coal equivalent" by taking 3 lbs. of wood as equivalent to 1 lb. of coal. This is, if anything, rather unfair to the wood, so that the average coal consumption figures given for drying only, especially in the Dooars, should, if anything, be increased somewhat, but this does not apply to the figures stated for the estates using steam heating as, on these estates, coal only has been used.

The main item in the cost of fuel on a tea garden is the transport which frequently costs more than the coal at pit-head, or oil fuel at the refinery, and transport costs vary greatly with the situation of the garden, not only in regard to length of the route, but also in regard to local communication with the nearest railway station.

It has therefore been thought better not to show the actual cash saving realised by the "All Steam" system in the different districts, but to show the amount of coal that is represented by the cash saving on the estate concerned, and this has the further advantage that an estate which formerly used oil engines for power and/or oil fuel for drying can be brought on to the same basis of comparison.

It will be seen from the tables that, in all cases, a very substantial saving has been effected in fuel costs by converting to the "All-Steam" system.

Assam.—Garden "A," where an oil engine for power and coal for drying were previously used was converted to the "All-Steam" system for the 1939 season and returns a total figure for power and drying of 1.27 lbs. of coal per lb. of tea, as against a district average for the three preceding years, on 24 other estates, of 1.2 lbs. for drying only. The saving on this estate, compared with 1938, is equivalent to the cost of .5 lb. of coal per lb. of tea, on a crop of 1,003,840 lbs. of tea excluding any allowance for the elimination of stove and chimney renewals, and lower maintenance costs of steam plant, as compared with an oil engine.

Dooars.—Garden "B," where a separate coal fired steam plant for power and coal for drying was used formerly, was converted to the "All Steam" system in 1939 and returns a total figure for power and drying of 1.65 lbs. of coal per lb. of tea. The season started with unusually small crops for the first three months and, up to the end of July, only 356,000 lbs. of tea had been made, with an expenditure of 2.07 lbs. of coal per lb. of tea. From August to November inclusive, 659,200 lbs. of tea were made with a total fuel expenditure of 1.4 lbs. of coal per lb. of tea. It is, therefore, reasonable to suppose that, in a more normal season, the fuel consumption would not exceed 1.5 lbs. per lb. of tea and would probably be better than this when more experience had been gained in working the plant. This same factory, in 1936, used a total of 2.64 lbs. of coal per lb. of tea for power and drying and it will be observed that the average of eleven other gardens for drying only for the previous three years — 1936, 1937, and 1938 — is 1.29 lbs. of coal per lb. of tea (and, as mentioned above, on account of the larger amount of wood used in the Dooars, this figure should probably be increased). The saving achieved, compared with with 1938, on a crop of 1,053,520 lbs. is equivalent to .61 lb. of coal per lb. of tea, excluding any allowance for elimination of stove and chimney renewals.

[Up to the end of August, 1940, the date of the latest available figures, garden "B" made 682,000 lbs. of tea with a coal consumption of 1.61 lbs. per lb. of tea, whereas, to the end of August, 1939, 580,000 lbs. had been made with 1.78 lbs. of coal per lb. of tea.

Moreover, another estate in the Dooars converted for the 1940 season returns a total coal figure up to the end of August, 1940, of 1.28 lbs. of coal per lb. of tea.]

Sylhet.—Garden "C" is the one referred to in the opening paragraphs where a steam heating plant was first installed in 1937, and the staff have had three years' experience in working the plant, which replaced a separate steam plant for power and coal for drying. It is interesting to record that, for both the 1938 and 1939 seasons, the same total coal consumption figure, *i.e.*, 1.07 lbs. of coal per lb. of tea for power and drying, is returned, whereas the average of fifteen other gardens for the previous three years is 1.05 lbs. of coal per lb. of tea for drying only, so that this factory has achieved the remarkable result of obtaining power and drying for only 2 per cent more fuel than the other factories have used for drying only and, compared with 1936, when the total coal consumption for power and drying was 2.06 lbs. of coal per lb. of tea, there has been a saving of 48 per cent. The saving achieved in comparison with 1936, on a crop of 1,009,440 lbs. is equivalent to .94 lb. of coal per lb. of tea, excluding any allowance for elimination of stove and chimney renewals.

[This factory up to the end of August, 1940 has made 592,320 lbs. of tea with a coal consumption of .91 lb. per lb. of tea.]

Cachar.—Garden "D" was converted to the "All-Steam" system in 1939. This estate previously used an oil engine for power and oil fuel for drying, and it is surprising to find that, using the new system with coal only, the total figure for power and drying is 1.39 lbs. of coal per lb. of tea, which is less than the average of five other estates for drying only. The saving realised on this estate compared with 1938, on a crop of 538,000 lbs. is equal to the cost of 1.14 lbs. of coal per lb. of tea, exclusive of any allowance for elimination of stove and chimney renewals.

It therefore appears reasonable to expect, that, by installing the "All-Steam" system, the total fuel for power and drying will not be more than 20 per cent above the amount normally used for drying only, whether it be wood, coal, or oil, and is likely to be less than this, so that in a factory using modern dryers which can show a figure for drying only as low as .5 lb. of coal per lb. of tea on the season's working, it should be possible to get down to about .6 lb. of coal per lb. of tea for power and drying with the "All Steam" system.

In addition to the saving in fuel, there are the great advantages of drying at a constant temperature, of having steam available for sterilising rollers and sifters, etc., and of the elimination of stove and chimney renewals. In large factories, there is likely to be a reduction in the number of stokers required.

Where stoves are in existence, they may be retained and the steam heater arranged above, or adjacent to, the stoves, with suitable air ducts and valves, so that either the stove or steam heater can be used as required; but, seventeen of the twenty Steam Heated dryers working during 1939 had the stoves removed, and a further seven dryers converted for the 1940 season are also without stoves.

It should be emphasized that the great economy achieved by the "All-Steam" system is due to making full use of the heat in the exhaust steam and it is perhaps not generally realised that a steam engine utilizes not more than 10 per cent of the total heat in the steam, the remaining 90 per cent being wasted in the exhaust, all of which in the new system is utilized for heating the air for the dryers.

There is a further considerable saving due to the elimination of the fuel used for lighting up the dryers, as the amount of fuel required for keeping the boiler plant banked at night is very con-

siderably less than normally used for lighting up the dryers. The saving from this source is so considerable that it is worth while considering the desirability, where oil engines are comparatively new and in good condition, of installing the necessary boiler plant and steam heaters, to be worked on live steam until the oil engines need replacing, when steam plant would be installed to enable the maximum economy to be achieved. It is interesting to record that several large factories in Kenya use live steam heating for the dryers, and have found that it is more economical than direct firing in the normal manner.

There is nothing about the situation or arrangement of any of of the factories from which these figures have been obtained, which makes them in any way peculiarly suited to the use of steam heating for drying. The economies indicated may be confidently expected from the application of this system to any factory, by using in the boiler plant the same fuel, whether wood, coal, or oil, that would normally be used in the dryers. There are, moreover, several advantages, the value of which cannot be directly measured in cash, these are: cleanliness, owing to dirt and dust from fuel being confined to the boiler room, convenience, especially the convenience of being able to start up any dryer without having to light up a stove and wait for the dryer to be warmed up — and, above all, absolute control of temperature, adjustable, but, when set, automatic in its action.

There is no reason why the results obtained in North-East India should not apply in Ceylon, so that by installing the "All Steam" system the total fuel consumption for power and drying in a Ceylon factory should not exceed that used for drying only by more than 20 per cent, and is likely to be less than this. The additional fuel used for providing warm air for withering should remain approximately the same.

STUDIES IN THE YIELD OF TEA

IV.—THE EFFECT OF CULTIVATION AND WEEDS ON CROP GROWTH *

T. EDEN

Introduction.—The culture of plantation crops lacks the settled tradition that lies behind farming practice in temperate lands. Tropical agriculture has borrowed ideas freely from temperate agriculture, in most instances imitating operations associated with annual crops. The most persistent of borrowed traditions are those which stress the need for thorough cultivation and the complete suppression of weeds. Their unquestioned acceptance in Ceylon has in the past overridden all other considerations, and differences in crop and circumstances have been given little consideration. The facts that annuals need a seasonal preparation of a seed-bed upon which small seed can germinate and in which young seedlings can grow, and that cultivation is in the first place intended to produce this seed-bed, are largely irrelevant to a perennial crop such as tea, which is generally raised in a nursery for a period varying from six months to two years before transplanting in the field. In addition, heavy rainfall has generally appeared to be a further reason for cultivation in order to 'aerate' the soil. The converse problem of soil-erosion control has only recently been adequately realized. Vigorous cultivation and clean weeding with a scraping instrument have in the past undoubtedly hastened the process of soil erosion on the generally steep slopes of Ceylon's tea area.

The study of cultivation problems has been slow both at home and abroad for lack of means of measuring and expressing in a quantitative form so qualitative a conception as 'tilth.' Only since doubts about the need of specially vigorous cultivation for annual crops were voiced at home have the still more cogent doubts about advocating it for perennial crops made any impression in Ceylon planting circles.

* Reprinted from *The Empire Journal of Experimental Agriculture* 1940, Vol. VIII, pp 269-79.

Previous Work.—The trials at Rothamsted and Cambridge have independently shown that some of the traditional notions in regard to cultivation would have to be revised. In a series of experiments on rotary cultivation, ploughing, sub-soiling, hoeing, and rolling, the outstanding results have been that 'thorough' cultivation affects germination and early growth by the production of a good seed-bed, but makes little or no contribution to final yield. On some occasions the contrary process of rolling has increased the crop. The only beneficial effect of cultivation during the period of crop growth is attributable to weed destruction. [1, 2, 3, 4]

The data on cotton and tea are more relevant to tropical conditions. Heath [5], working on cotton, found no advantage in growth and development following specially deep cultivation. A pulverizing roller applied after the harrow gave a beneficial effect. For various reasons he doubts whether extra cultivation helps soil aeration. In the first place it produces no increase of nitrate in the soil. Furthermore, cotton can grow quite normally in containers hermetically sealed. Maize and barley have been grown in completely waterlogged tropical soils provided that the nutrient-supply was adjusted [6].

Cooper [7] has tried various treatments on tea in Assam. The standard implement is a hoe which penetrates about 7 in. into the soil for deep hoeing, and for light work cuts a sod $9 \times 12 \times 3$ in. and turns it over on to the bare space left by the last sod cut. The essential point is that the surface-soil is as completely severed from the lower layer as if it had been ploughed. To destroy weeds, one deep hoe at the beginning of the season is normally followed by six light hoes spread over six months. Cooper investigated various combinations in hoeing programmes along with hand-weeding and a scraping operation that destroyed weeds but did not appreciably stir the soil. According to Cooper's findings, cultivation conferred no benefits so long as weeds were controlled by scraping or hand-weeding. Deep hoeing damaged roots sufficiently to check growth early in the season. The consensus of opinion on a variety of crops is therefore against specially vigorous cultivation.

SCHEME OF INVESTIGATION

The chief source of information in the following investigation is a field experiment with tea that has completed a three-year pruning cycle (1936-9) in which the main factors studied were, — cultivation, weeding, and manuring. Set out in full, the comparisons, arranged in pairs, were:—

1. *Clean weeding* v. *selective weeding*.—Clean weeding involved the removal monthly of all weeds, and selective weeding the removal at the same time of all grasses and non-herbaceous weeds. Where necessary, the remaining weeds were slashed just above ground-level to prevent interference with tea plucking.

2. *Intensive cultivation* v. *normal cultivation*.—The former consisted of three cultivations per annum spaced at three-month intervals, except that the forking due in March was omitted owing to dry weather. Normal cultivation consisted of one forking only at the time the manures were applied. The type of cultivation was what is locally known as 'envelope' forking. A three-pronged fork is driven into the ground, levered backwards and forward, and slightly raised till a pocket forms behind it ; into this, leaf-mould and green-manure are pushed, after which a fresh 'envelope' is made adjoining it across the width of the cultivation row. This leaves a ridge and hollow, and the series of ridges and hollows so formed run parallel to each other about 9 in. apart. The soil mass is not completely inverted.

3. *Double manuring* v. *single manuring*.—The single dose provided per acre : nitrogen 40 lb., phosphoric acid 30 lb., potash 20 lb. Applications were made annually. Every plot received one of each of the above main treatments so that all possible combinations were obtained within the compass of eight treatments.

4. *Adco compost* v. '*no Adco*.'—Replications of the above treatments were laid down on six areas that had for the previous four years received 15 tons per acre per annum of Adco compost, and also on six corresponding areas not so treated.

The effects of these various treatments were studied in relation to three characteristics: (*a*) the resistance of the soil to the penetration of a probe; (*b*) the volume and depth-distribution of feeding roots; and, (*c*) the yield of tea. Details of the technique used are given in the following sections.

EFFECT OF CULTIVATION AND WEEDS ON SOIL RESISTANCE

The soil probe designed by Culpin [8] has given under our conditions a clear and definite picture of the deterioration of the macrostructure of the soil after cultivation. Sieving tests similar to the those carried out by Keen [9] were attempted, but proved unsatisfactory in a soil that carried a crop continuously and was permeated by roots of very variable dimensions.

(*a*) *Untrodden soil*.—For purposes of comparison, preliminary measurements were made on a fenced and untrodden area in the same field as that containing the experiment. This area was without crop, but was otherwise identical with the experimental area in all essentials. After 'envelope' forking, the ridges were lightly levelled in order to afford a reasonable datum line, and probe-measurements were made. Thereafter the land was divided up into six plots of which three, in randomized order, were covered with a 3-in. thatch of a tall grass (*Andropogon nardus*). In this condition they remained for 17 months. After 5 months, and again after 17 months, resistance-measurements were made with the probe. In doing this no trampling was done and the mulch was disturbed as little as possible. The results obtained give information on the effect of rain, wind, and sun on the permanence of the forking effect. Since there was marked similarity between the measurements at 5 and 17 months, the latter only are considered here in relation to those made at the beginning of the period.

Fig. 1*a* shows the soil resistance in lb. at successive $\frac{1}{2}$-in. depths up to 9 in. for the initial and final probe-surveys on mulched untrodden soil. The wearing-off of the cultivation effect has been negligible. The instrument has a constant due to friction and its own weight, amounting to some 8 lb. The extra force necessary to ensure penetration to 9 in. just after forking is 2 lb. and is actually more than that necessary 17 months later. The scale adopted is a very open one and shows differences that may well be ignored in any practical interpretation of the results. Fig. 1*b* gives similar traces for the unmulched plots; the resistance is throughout smaller than for mulched plots. The reason for this is obscure, but the point of interest is that the traces for the different times are identical, due allowance being made for the error of the determinations. This comparison of mulched and unmulched plots makes it clear that the heavy rain of two monsoons and the intermittent drying produce no crust on unprotected soil. This finding is in marked distinction to those of Hénin [10] on temperate soils at Versailles. Hénin describes the destruction of the macrostructure by rain, and the formation of a well-defined crust which the removal of the probe occasionally detached from the general soil mass. Evidently the crumb structure of this Ceylon soil is more water-stable than that of Hénin's soil. This divergence cannot be regarded definitely as of general significance in distinguishing temperate and tropical soils until confirmatory data are available, but it is noteworthy that the greater water-stability of tropical soils is recognized as a factor in minimizing soil erosion, and has been commented upon in this connexion by the writer [11] and by Jacks and Whyte [12].

(*b*) *Trodden soil.*—The soil between the rows of tea (usually 4 ft. apart) is constantly trampled after cultivation. For purposes of plucking, weeding, and shade-tree control there is traffic under all conditions at approximately weekly intervals. Very frequently the soil contains so much moisture that in temperate agriculture no work on land in a comparable physical state would be contemplated. The effect of this treading on the soil macrostructure is marked.

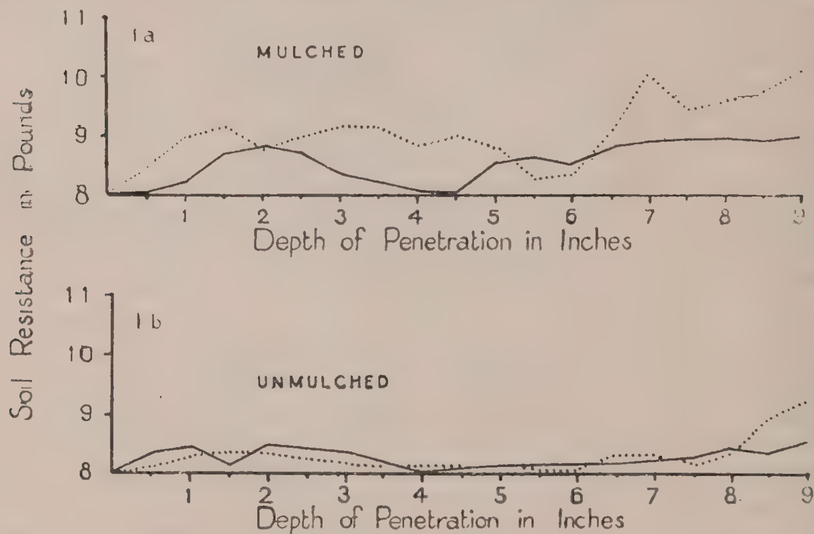
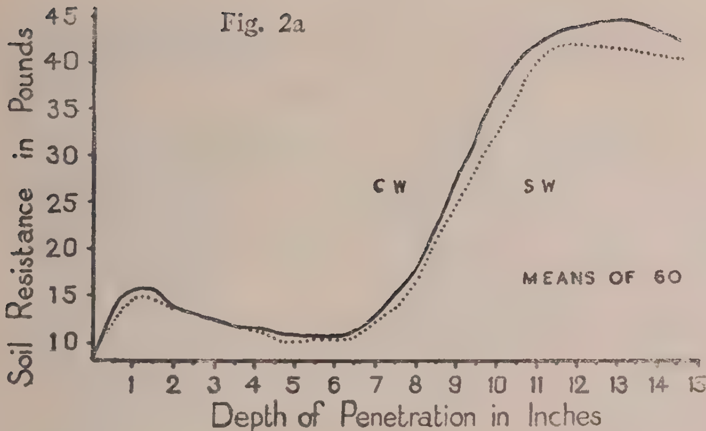


Fig. 1. Soil-resistance measurements. Dotted line: immediately after cultivation. Continuous line: seventeen months later.

Fig. 2*a* shows two soil-resistance curves taken $2\frac{1}{2}$ years after the previously mentioned field experiment had been started, *i.e.*, when the differing treatments had been given time to become effective. One curve represents the mean values for normal cultivation (N.C.) and the other for intensive cultivation (I.C.). Disregarding for the moment their difference in detail, both follow a definite pattern. They show a rise in resistance in the first $1\frac{1}{2}$ to 2 in., followed by a decrease to a new minimum between 4 and 6 in., after which there is a sharp rise in the region of less-disturbed soil till finally an approximately constant value is reached beyond the depth of cultivation. Fig. 2*c* gives similar data from a small-holding which, as far as is known, has received no cultivation in the ordinary sense since the original planting. From time to time weed-growth has been scraped off without any soil-stirring. The same general curve-form is shown. The formation of a resistant crust due to treading is very evident and contrasts with its absence in Fig. 1.



CORRECTION SLIP.

Tea Quarterly, Vol. XIV, Part II, Page 52. Figures 2a and 2b have been transposed. The top diagram should read 2b and the middle diagram 2a.

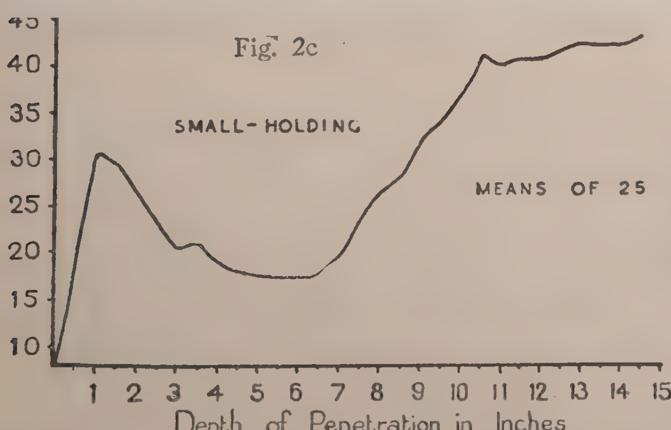


Fig. 2. Soil-resistance measurements: (*a*) Normal cultivation (N.C.); intensive cultivation (I.C.) (*b*) Clean weeded (C.W.); selectively weeded (S.W.) (*c*) Uncultivated small-holding

In greater detail Figs. 2*a* and 2*b* show the effect of intensive cultivation and weeding on the general shape of these curves. The curve for normal cultivation (N.C.) represents the position 9 months after a cultivation operation, whereas the intensive cultivation (I.C.) plots had been worked on only 3 months previously. Even with intensive cultivation, a treading crust rapidly forms under conditions heretofore described. The more frequent cultivation reduces resistance, though but slightly. But after 9 months' treading, the region beneath the surface-crust is still remarkably open and after 3 months is demonstrably in the same condition as at the time of forking. Fig. 2*b* shows that a weed-cover makes no difference to the formation of the trampled crust. This crust effect may be compared with that formed on English farms by sheep-treading, except that in tea soils it is completely dissipated by the type of cultivation subsequently employed.[13]

It will be shown later that the crust appears to have no effect on the development of the root-system ; but it has an important relationship to soil erosion. Lowdermilk [14, 15] has shown that the formation of a silted and puddled surface-layer of soil determines the percolation-rate of rainfall for the entire soil profile, and thus regulates run-off. Gorrie [16] draws attention to the trampling of soil on heavily grazed grasslands in the same connexion. This type of percolation-control undoubtedly occurs on tea soils. It is commonly observed that where a trodden path crosses a drain or silt-pit capable of collecting run-off, there is invariably a cone of deposited soil heaped up against the vertical drain-wall on the upper side.

EFFECT OF CULTIVATION AND WEEDS ON ROOT DISTRIBUTION

The main difficulty in root-investigations is to perfect an adequate technique. The system of selection of typical bushes from whose roots soil is washed away, so that roots can be photographed or plotted *in situ* with regard to a reference frame, has been used with success for a plantation crop by Nutman.[17] The usefulness of this method depends on the degree of certainty with which the small number of chosen bushes can be regarded as typical, and serves well to establish qualitative differences of root-structure either between related species or between markedly different habits. It is ill-fitted for studying the effects of cultivation treatments where less importance is attached to minute detail of root-disposition than to the general reaction to treatments within the range of their effectiveness. As an alternative capable of giving a quantitative picture, a method of random soil-sampling and root-separation has been

adopted This has not been wholly satisfactory, though for each treatment 48 samples were examined. The technique adopted was as follows :—

Samples were taken midway between the rows of tea with a wrought-iron box sampling-tool measuring $8 \times 8 \times 3$ in. This was driven into the soil with a wooden ram, and on two opposite sides the soil was cleared to the depth of the lower edge of the tool, *i.e.* 3 in. By using a curved-handled turf-lifter inserted underneath the tool, the block of soil in its container could be cleanly sliced from its position. This procedure was repeated for eight successive 3-in. depths without any great difficulty and without undue excavation for working-space. When trial samples were washed out it was found that the lowest layer contained on the average only about 4 per cent. of the weight of roots separated from the whole 24-in. soil prism. This depth was adopted in subsequent samples, since it was greater than the cultivation-depth and was well below the region in which the soil probe-resistance became stabilized. The roots were easily floated off from the soil by running a stream of water over the sample and stirring the soil meanwhile in a shallow, lipped container. The overflow was passed through a small sieve in which the clean roots were collected ready for drying and weighing. Only feeding-roots were recorded.

Since the sample size was quite arbitrary and only comparable values are required, the results for the various treatments are expressed on a percentage basis (Table 1).

TABLE I

Effect of Cultural Treatments on Total Root-weights to a depth of 24 in.

	Treatment	Per cent. mean weight (means of 48 samples)
(*a*)	Normal cultivation	105
	Intensive cultivation	95
(*b*)	Clean weeding	96
	Selective weeding	104
(*c*)	Single manure	99
	Double manure	101
(*d*)	With Adco	103
	Without Adco	97

The differences between the individual constituents of the pairs are in no instance significant at the $P=0.05$ level of probability, though the effect of intensive cultivation is nearly so. Possibly with a larger number of samples a negative result might have been avoided, but an increase in sample number would have created difficulties. Altogether 768 sub-samples were examined. Sampling was quicker work than washing, and a larger number of samples would have meant either a longer sampling or a longer storage period, neither of which was desirable.

In any case the results show that treatments of this type have a very narrow range of effectiveness in destroying mature, or in stimulating new, roots. In view of yield-differences to be reported in a later section, the figures for Adco are of particular interest. They give no support to the suggestion frequently made in Ceylon that bulk manure enhances root-growth apart from its effect on plant-nutrition.

The sampling of the roots by sections enabled the distribution of feeding-roots to be studied. In addition to the survey carried out on the cultivation-experiment, two further areas were included in the investigation. One was a similar area carrying older tea, and the other was a dissimilar area consisting of the aforementioned small-holding. The weight of roots in each sub-sample is expressed as a percentage of the total root-weight (Table II).

The first 12 in. of soil in the three localities contain about 70 per cent. of the roots. It was originally thought that the even distribution in the first 12 in. was due to cultivation, since the depth corresponds closely with the depth of soil-stirring as shown by probe-measurements. But when the small-holding samples were complete, the similarity in pattern maintained by the depth-distribution figures showed that conjecture to be ill-founded. It appears likely that the similarity is due more to uniformity in soil than to soil treatment. That there is a marked difference in total roots, as a result of cultural treatments, is shown by the last line of the table, which gives the total root-weights from the old and small-holding tea as a percentage of the young tea.

EFFECT OF CULTIVATION AND WEEDS ON CROP YIELDS

The most complete picture of the effect of cultural treatments on tea is given by the crop yields. The area used for the experiment was originally clean weeded and received uniform cultivation of the type here described as normal. Some time elapsed, therefore, before the effect of treatments became evident. Table III shows

the gains and losses due to weeds and cultivation in combination with other variable treatments. Displayed in this way, the interactions between treatments are easily demonstrated, but in point of fact none of them was significant. From inspection of the mean yields (to which criteria of significance are attached) the effect of treatment is seen to start in the second year and to be maintained through the third year. Treatment effects are significant over the three-year cycle considered as a whole. The extent of the weed effect is surprisingly small. Cultivation has had a definitely significant but small adverse effect. The non-existence of an interaction between weeds and manurial dose is of particular interest. Admittedly the extra dose was a heavy one for such young tea, and has sufficed for the requirements of both tea and weed-cover.

TABLE II

Distribution of Feeding-roots in successive 3-in. Layers
(Percentages of Total Root-weight)

Layer (in)	Young tea (Experimental plots) cultivated	Old tea cultivated	Small-holding uncultivated
0-3	18	16	16·5
3-6	18	17	17
6-9	19·5	17·5	17·5
9-12	17·5	17·5	16
12-15	10·5	13	11
15-18	7	8·5	9
18-21	5·5	6	7
21-24	4	4·5	6
Total ...	100	100	100
Per cent in first 12 in.	73	68	67
Total root-weight as per cent of young tea ...	100	155	50

TABLE III

Effect of Cultivation and Weeds on Crop Yield

A. Gain or Loss in Yield due to Weeds; lb. per acre per annum

Treatment	1st year	2nd year	3rd year	Cycle
Intensive cultivation ...	–5	–53	–51	-37
Normal cultivation ...	–13	–107	–43	–54
Single manure ...	–9	–77	-50	–46
Double manure ...	–9	–83	–43	–45
Mean ...	–9	–80**	–47**	–46**
Percentage ...	5.0	10·0	7·5	8·6

B. Gain or Loss in Yield due to Intensive Cultivation; lb. per acre per annum

Treatment	1st year	2nd year	3rd year	Cycle
Clean weeding ...	–4	-75	-33	-37
Selective weeding ...	+4	–21	–41	-20
Single manure ...	+6	–23	–18	-12
Double manure ...	–7	-73	-55	–45
Mean ...	0	–48*	–37*	–28*
Percentage ...	0	6·0	5·9	5·3
Mean annual yield per acre per lb. ...	180	798	627	535

Significant values P=0.05*; P=0.01**

EFFECT OF BULK MANURE ON YIELDS

The effect of the pre-treatment of the sub-blocks with Adco manure was apparent throughout the whole experiment. Visual inspection of the plots showed that those areas receiving the bulk manure produced rows of tea that covered the ground more completely than their counterparts not so treated. The most striking difference was between the shade trees (*Erythrina lithosperma*) on the two areas: establishment and growth were good where Adco was applied, but were a failure elsewhere.

The total amount of plant-nutrient applied as bulk manure was considerable and the yields have benefited accordingly. After pruning, and before normal plucking started, the young developing shoots are allowed to grow for some 4 months and then tipped, *i.e.*, broken back to 4 in. from the pruning-cut. The dry weights of this new growth were found to be 217 lb. per acre for Adco plots and 111 lb. per acre without Adco. Table IV gives the effect of Adco over the whole cycle and the effect of Adco on the yield-increases due to the application of artificial manure.

The tipping operation, being a levelling one, robbed the yield-difference in leaf for the rest of the first year of its significance, but thereafter a highly significant effect was produced. There was no significant interaction between Adco and the different levels of artificial manuring.

TABLE IV

Effect of Adco and Artificial Manure. Yield-increase in lb. per acre due to Adco

	1st year	2nd year	3rd year	Cycle
Single manure with Adco ...	31	151	146	110
Double manure with Adco...	35	169	169	124
Mean ...	33	160**	158**	117**
Percentage ...	8.3	20·0	25·2	21·9
Mean yield per acre ...	180	798	627	535

DISCUSSION

The results of the investigations here reported have a definite bearing on agricultural practice on tea estates in Ceylon. They tend to confirm the view that moderation in all cultural operations gives the best results. No extra crop is to be expected from frequent cultivation, a result consonant with Cooper's findings (*loc. cit.*), As far as can be told, the intensive stirring of the soil makes no difference to the distribution of the root-system, and is no help at all, but probably a hindrance, to the production of a large volume of of feeding-rootlets. The slight pan that is formed by the constant treading does not impair the distribution of roots in that region, and the main reason for forking as judged from these experiments is to break up that pan in the interests of soil erosion and run-off control, rather than to obtain living-room for the roots. Annual forking is ample, and the spreading of that operation over two six-month periods in alternate rows (a method very common in Ceylon in order to provide an occasion for the working-in of artificial or green manures as the latter mature) offers adequate soil disturbances to ensure good growth and yield.

The practice of clean weeding is shown on a short-time basis to give the best yield results, but the yield premium it gives is surprisingly small. If grasses are removed and other weeds controlled, a more or less complete carpet of soft weeds interferes but little with yield-potentialities, even in young tea where the lack of density of the major crop makes their growth quick. The practice of choosing, as a result of an actual trial, some three or four weeds which will give adequate protection against soil erosion, and of checking any slight yield-decline by extra manuring, appears to have distinct possibilities in conserving soil. On the basis of these experiments, the fear that the weeds, not the tea, would get the manure appears ill founded.

It would be premature to suggest that, since tea is a forest species, it should be allowed to grow under unrestricted or nearly unrestricted forest conditions. When a plant is taken as a crop plant, interference with its normal habits of growth must follow, and with tea the interference is severe. Without pruning, the crop of young leaf suitable for manufacture would be insignificant, and, since rapid growth of young shoots is desired, free play to the stabilizing influence of natural ecological competition seems impossible. But there is room for a movement away from extreme positions in the interests of soil conservation.

SUMMARY

1. The effect of intensive cultivation, and of leaving a selected weed-cover in a tea experiment is described with respect to (*a*) soil resistance, (*b*) volume and distribution of roots, (*c*) yield.

2. Tea soils under cultivation programmes of very varying intensities show a characteristic pattern in their resistance to the Culpin soil-probe at depths up to 24 in. A surface-crust forms, not as a result of rain or other weather conditions, but as a result of continual treading. Beneath this crust the soil remains porous for a considerable time after cultivation. The surface-crust is an important predisposing cause of erosion.

3. Root-development also shows a similarity in distribution irrespective of cultivation, but root-volumes are markedly different under different cultural conditions. Intensive cultivation probably, but not certainly, decreases root-growth. A technique of root-sampling is described.

4. Both weeds and intensive cultivation reduce yield, the former by 8.6 per cent. and the latter by 5.3 per cent. over a three-year period.

5. The effect of bulk manure on yield and root-growth can be explained only on the assumption that the mechanism is entirely nutritive, and that bulk manures do not stimulate root-growth in any other special way.

6. The bearing of these results on plantation practice is discussed.

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CLONE TESTING IN THE FIELD

(REVIEW)

T. E. T. BOND

In the previous issue of *The Tea Quarterly* (Vol. XIV, Part I), the present position of the tea selection programme in Java was reviewed and the need for clone-testing, *i.e.*, for the detailed examination of the yield and other characteristics of the vegetative progeny of selected mother trees, was emphasised with reference to the experiments carried out by the Proefstation West-Java at Tijnijroean. These experiments were necessarily on a small scale and involved the use of the "row-test" method, in which the material to be tested, usually seven clones and one control at a time, was planted in single rows of eight plants randomised in blocks to give a fourfold replication. The results obtained from the whole series of experiments led to the elimination of all but about ten per cent of the original number of clones tested. On the other hand many of those retained for further experiment were outstanding in yield and quality. A further paper by I. J. H. van Emden, received recently,* describes the arrangements which are in hand for the next and final stage in the process of clone testing, namely the trial of selected clones on a field scale by estates throughout the tea growing districts of Java and Sumatra.

SCOPE OF THE EXPERIMENTS

Eighteen estates have been selected in all to carry out the experiments, twelve in Java and six in Sumatra. They have been chosen to represent as many different types of soil and climate as possible and range from about 1,000 feet to 5,300 feet in altitude with average rainfall varying between about 100 and 170 inches. Some fifty to sixty clones are to be grown on each estate. The experiments are to be laid down on newly opened land on which no tea has been grown previously, and arrangements have been made with the Tea Control Authorities whereby the estates participating are to be permitted an extension of acreage of 7 hectares

* *Archief voor de Theecultur*, Vol. 14, pp. 91-117 (January, 1941.)

(about 17 acres) for this purpose. The maximum extension for scientific purposes during the 1938-43 restriction period is to be 150 hectares, which will allow a reserve of 24 hectares to be apportioned later should it appear desirable.

EXPERIMENTAL PROCEDURE

The general plan of the experiments is to grow the clones and their controls in plots of eighty bushes, preferably in the form of 8 rows of 10 plants each. Thus each plot will be comparable to the single row of eight plants employed as the unit in the Proefstation's row-test experiments. A five-fold replication is to be employed. There are obvious difficulties in treating the whole range of fifty or sixty clones to be tested on any one estate as a single experiment and so the expedient is being adopted of arranging the material in groups, each of at least six and at most eight varieties including controls, and each forming a self-contained randomised block experiment. By growing the same control material (which should consist if possible of a single standard clone in addition to seedlings of the ordinary estate quality) in each experiment, mutual comparisons between the experiments of a complex will be permissible and the value of the complex as a whole will be enhanced thereby.

Points of practical importance to be considered include spacing distance and the necessity of avoiding marginal influence between the plots. In these respects, uniformity of treatment is desirable on the different estates. The planting distance decided upon will be 3 feet between the bushes, with 5 feet between the rows. A 4×4 feet spacing was adopted for the Tijnjiroean row-test experiments. According to Hoedt and Schoorel (*Arch. Theecult.* 12:310-26), planting distance is inversely proportional to yield per given area during the first ten years only. After this time all planting distances except the extremely wide plantings with fewer than about 4,000 bushes per hectare (*i.e.*, about 1,600 per acre) tend to reach a similar level of yield although, as would be expected, this level is reached much more quickly by the closer plantings than by the wide. While, from this point of view, a close planting might be advantageous for experimental purposes, in practice, the spacing chosen must be determined largely by the planting material, *i.e.*, budwood, available. The position with regard to marginal influence is rather similar. Undoubtedly the best method of avoiding marginal influence would be to leave a clear two rows width round each plot. The rows would be planted with the same material as the plots concerned but would simply be omitted from the yield determinations. A moment's consideration will show that to do this

and still leave effective plots of 8 rows of 10 bushes each would more than double the amount of budwood required. The actual course adopted will be to leave narrow paths around each plot, thus effectively separating them without any increase in planting material. The chief objection to this method is that the strong growing clones will be unduly favoured in competition for the available soil represented by the area of the surrounding paths.

PLANTING METHODS

These were briefly dealt with in the previous article, although here again considerations of the amount of budwood available must weigh strongly in the final choice of method. *Budded stumps* or more accurately stumped buddings, plants which are budded in the nursery and planted out as stumps a year to eighteen months later, are definitely the best planting material. Their chief advantage is the rapidity with which planted fields come into plucking and the high percentage stand obtained. However, the number of stocks and amount of budwood which would be required *immediately* is very large. Thus, on any one estate, an experimental complex of 500 or so plots of 80 plants each would need 50,000 stocks for budding, allowing 80 per cent success. Again if one clone was to be planted in all eighteen estates undertaking the experiments, then at the same percentage of success, 9,000 buds would be needed, (*i.e.*, $80 \times 5 \times 18 \times 100 \div 80$). There is the added difficulty experienced in the transport of large quantities of budwood from Java to Sumatra. *Planting with seed or stumps and budding later in the field*, will involve a lapse of a long period of years between planting and bearing. However, the advantages of this method are great: (1) The experimental field can be planted up immediately and independently of the supply of clonal budwood, (2) The estates can meanwhile be raising their own stocks of budwood from small quantities supplied by the Proefstation. Transport costs will thereby be reduced and an increased percentage success will be obtained when the final budding is carried out. (3) The condition of the plants in the field before budding will serve as a useful guide to the degree of soil heterogeneity to be expected within the experimental area. The information derived can be made use of in the final apportioning of the land into blocks. It is expected that this latter method will be adopted in the majority of cases.

JUDGING THE RESULTS

Yield determinations will be made by taking periodic records of 6 to 10 consecutive pluckings. Such figures, as Wellensiek (*Arch. Theecult.* 12:1-70) has shown, give a reliable indication of

the total productivity for the pruning cycle. Before the clones come into bearing, however, they must be closely watched and placed in order of merit with respect to breadth of spread, density of shooting, amount of growth, flowering tendency, resistance to drought and diseases and pests, etc. This is especially important as far as the habit of the plant is concerned, particularly in relation to the spacing distance, which may not be at the optimum for all clones. Thus, records of this sort may sometimes lead to a clone being preferred for general purposes above another giving a somewhat higher yield under the particular conditions of the experiment.

CONCLUSION

There are many financial and other considerations involved in large scale co-operative experiments of this sort. The Java workers have been at some pains to ensure that the rights of the original owners of selected mother trees — clonal material from which may one day be planted on a very wide scale — are adequately protected, and they have also not neglected the interests of the estates which are carrying out the experiments for the ultimate advantage of the industry as a whole. A large amount of work will of course be required, particularly in the early stages for the upkeep of the experimental fields. In this connection a brief recapitulation of the scope of the experiments on each estate will not be out of place. The area allotted in each case is about 17 acres. If 60 clones are to be tested, *i.e.*, in the whole complex, this allows for 10 randomised block experiments each of 6 clones and 2 controls. Each experiment then consists of 5 blocks of 8 plots, each of 80 plants. The simplest calculation is of the total number of plants in the complex which is $(80 \times 8 \times 5) \times 10 = 32{,}000$. At 3×5 feet spacing, or 2,904 plants per acre, this represents 11.02 acres. The difference will easily be accounted for by the paths separating each plot, which were omitted from the calculations. The estate will reap the benefit of the extra acreage of tea which, under restriction, would not otherwise be allowed. However, should the experiment be a success, the Proefstation reserves the right to employ it wholly or in part as a "budwood garden" and to sell the budwood obtained thereby. In this case the estates will be entitled to a certain proportion of the budwood at half price, and any additional outlay required in maintaining the field will be defrayed. A royalty of 50 per cent on the sale of budwood will be paid to the estate which selected the original mother tree. These and other conditions and undertakings are embodied in legal agreements which the Proefstation is concluding with all estates participating in the selection and clone testing programme.

A REVIEW OF TEA MANUFACTURE IN 1941

J. LAMB

It is often said that human affairs can never mark time; they either progress or retrogress. Teamaking is still in 1941 a human affair, partly an art and not exclusively a science, although much progress has been made in the matter of scientific control and in mechanisation. Enlarging on this point, it may be said in general terms that science in teamaking is largely a matter of aiding, rationalising, and eventually reducing to a formula, personal judgment.

Without the aid of scientific methods it is scarcely possible to detail a successful method of manufacture. Mechanisation permits the application of scientific methods with precision and reliability, but we have not reached the stage where tea leaf can be delivered to pre adjusted machinery and chests of high quality product turned out without further human intervention.

Nobody will dispute the fact that teamaking is a matter of a good deal of personal judgment and I doubt whether anybody will dispute the folly of trying to mark time which is tantamount to slipping backwards.

At the present moment we are in a position where the temptation to attempt the impossible feat of marking time is very strong. Government contracts and high local prices are tending to stifle the progressive spirit which is stimulated by open competition, and if this state of stagnation persists we shall find that standards of manufacture and quality will inevitably deteriorate.

The theme of this article is an earnest appeal to all concerned to prevent this deterioration gaining impetus. I will not go so far as to say that any deterioration has actually started, but I will say that there are some signs and symptoms if recent circulars on the subject of foreign matter be taken into account.

In present circumstances nobody can reasonably expect the normal rate of progress to be maintained as there are many difficulties to be faced both outside and in the tea factory, not the least of which

is the question of materials which I will enlarge upon later on. I maintain, however, that some rate of progress, however slight, must be aimed at in order to prevent or reduce trouble in the future.

I have expressed my fear of deterioration in the general level of quality of Ceylon tea. Some will deny the fact that the general level of quality has improved in recent years, and will say that Ceylon cannot make the same quality teas that were made fifty years ago. On the evidence available I do not believe any such statement, but apart from this I must explain that in this article I am employing the word "Quality" in a wider sense than it is used in the factory: the sense in which "Quality" is used in general commerce. The quality of a commercial product involves many factors which in the case of tea are perhaps more than usually complicated. Amongst the factors for tea are:—

(1) *Suitability for Some Special Purpose*, *e.g.*, blending, direct packing, or special demands (O.P's, tippy teas, etc.). Varying combinations of other factors are involved: (a) Appearance, (b) Strength, (c) Colour, (d) Pungency, (e) Flavour, (f) Size of grades and weight per chest (suitability for packing and blending machinery), (g) Keeping quality, (h) reaction to milk, etc.

(2) *Standardisation.*—Marks which are known to be reliable in respect of certain characteristics undoubtedly command a premium in the same way as other trade marks establish a reputation for reliability and are bought by those unwilling to experiment with unknown brands. Even the container has a sales value. In the case of tea chests the chests and the linings have a second-hand value and badly packed teas liable to damage in transit are naturally avoided by buyers. Our experiments with new lining materials forcibly demonstrated the value which buyers place on scrap metal foils. Under peace-time conditions they rejected certain linings solely because they lacked scrap value, unfortunately in spite of superior moisture-proof qualities.

(3) *Foreign Matter.*—Freedom from obvious foreign matter is of the greatest importance to any commercial product and may even involve legal proceedings where the foreign matter is objectionable or deliberately added (see 4.)

(4) *Conformity to Food and Drug Regulations.*—Regulations concerning foods and drugs tend to become more and more stringent and it must be recognised that such regulations are very desirable. In the case of many products, including tea, they protect the *bona fide* producer from competition by substitutes and adulterants and by resale of re-dried spent leaves.

The importance of factors such as (3) and (4) is not generally realised and will be dealt with more fully later in this article.

Research on tea manufacture is concerned with all these factors and is sometimes monopolised for some considerable time by special circumstances such as a Food and Drug Regulation which demands special attention to some particular feature of production.

Research on tea manufacture is not therefore solely a search for the best rolling pressure or firing temperature but a systematic investigation of the whole field of quality with the object of raising the general standard of the industry's products. Likewise progress in the factory is a matter of attention to all the factors involved in the wider conception of quality following, but not necessarily waiting for, the lead given by research.

I have called this article a review because I intend to cover, as far as possible, the whole field of quality and this I shall do in roughly the same order as that in which I have already enumerated the factors concerned. The review is therefore divisible into three parts:—

1. General Manufacture.
2. Foreign Matter.
3. Tea in relation to Food and Drug Regulations.

1. GENERAL MANUFACTURE

Success in tea manufacture is undoubtedly based on attention to detail and the production of teas of uniform quality, possessing the characteristics most desired by the buyers in the particular market in which the teas are sold. There is a good deal of confusion of thought and advice in this matter and to me it appears that the normal channels through which information about buyers' requirements filter through to those concerned with manufacture, leave much to be desired In our reports on various investigations concerned with manufacture we have repeatedly stressed the difference in the requirements between a buyer in London and a buyer in Colombo, and the work with the Clivemeare roller brought out further differences between the various London buyers and, in particular, between the blenders and others.

These differences are sometimes very striking, judging by comparison of reports on identical samples. Furthermore, they are not due to chance but are very consistent, and we have had every opportunity of proving this since many hundreds of experimental samples have been sent to tasters engaged in all the various markets of the tea trade.

An understanding of buyers' requirements is therefore of great importance, but at the same time it is essential to maintain a uniform level of quality if the buyers' confidence is to be gained and kept. Thus we arrive at the point where we must consider the first and foremost practical step in the factory — organisation.

Some of the best organisation is done before the factory is built, for much ultimately depends on withering space and facilities and the regular supply of adequate batches of withered leaf to the rollers. Again, in the rolling room good accommodation in the rollers is to a large extent invalidated if the roll-breaking accommodation does not match, since rollers are kept waiting for the roll breaker and certain desirable combinations of rollers may be impossible on this account.

Finally, a good consistent output from the rolling room necessitates matched capacity in the drying room or else leaf accumulates on the fermenting tables and the fermentation period has to be longer and longer as the day passes.

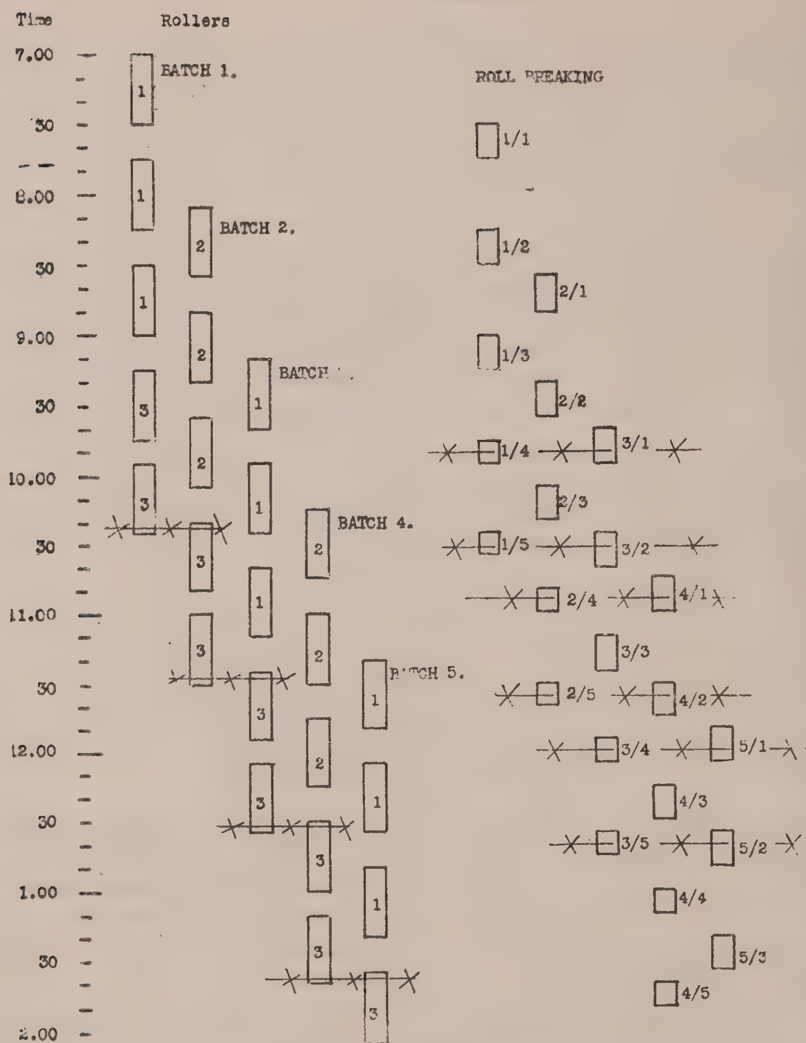
Clearly therefore equipment must in the first place be carefully planned and in the past this has been badly neglected. There has been much improvement in this respect in recent years but it is remarkable how many factories even now have badly matched capacities in the equipment of rolling and firing rooms. Reference to this point was first made several years ago in *The Tea Quarterly* and since that time it has been stressed repeatedly.

In 1937 Mr. F. J. Whitehead gave a paper on organisation at a T. R. I. Conference, a full account of which appeared in *The Tea Quarterly*. At the last Sub-Conference Mr. Whitehead enlarged on the same subject and made very valuable suggestions for certain compensations such as those for rise of temperature in the fermenting room towards mid-day.

Close attention to the matter of organisation has revealed many glaring mistakes which had been overlooked since the industry began. The numerous successive stages make tea manufacture a complicated business and extraordinary mistakes can be overlooked until the whole process is systematised.

A common fault in the past has been to charge more rollers in a given period than the firing machines can deal with. Consequently fermented leaf accumulated as the day progressed and it became impossible to control the fermentation period after the first set. Suppose for instance 400 pounds, approximately, of leaf are charged into the rollers at 7 a.m., 400 pounds at 7-45 a.m., 400 at 8-30 a.m. and so on (*e.g.*, two rollers with 200 lbs. = 400 lbs.; 1st roll of 30 minutes plus 15 minutes for emptying and recharging =

Diagram I.



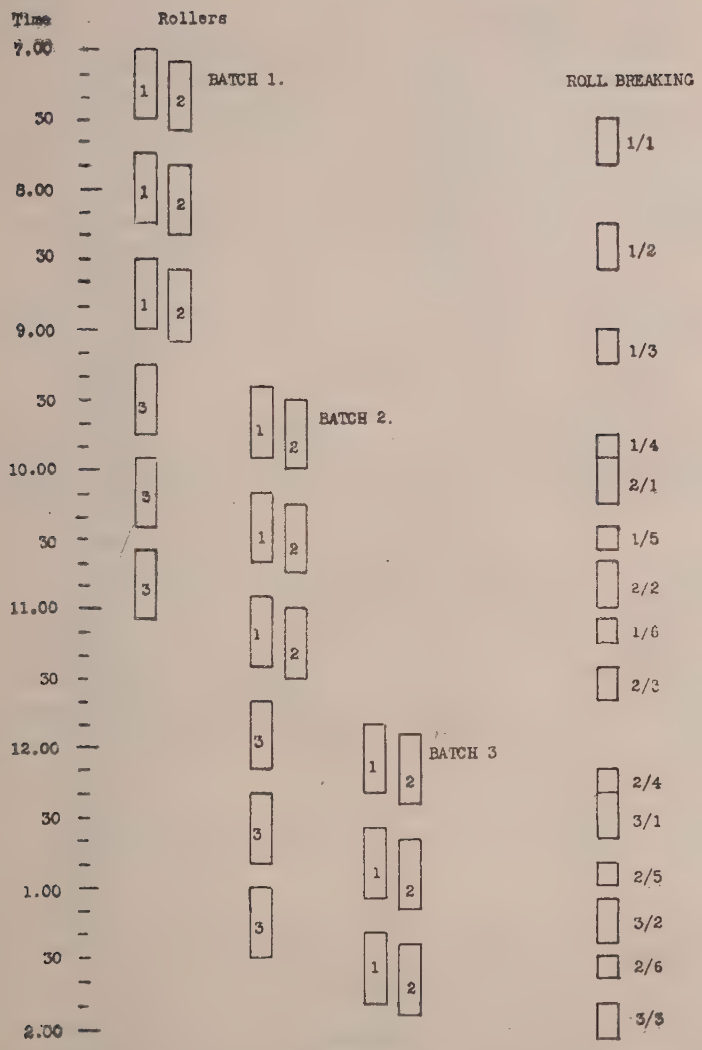
Details.

5 Roll-programme for 3 rollers and 1 roll-breaker.
Charge — 260 lb.
Charging interval — 65 mins.
Out-turn rolled leaf — 3.8 lb. per min.

Comments.

This is a badly arranged programme. There is confusion in the use of rollers, as No. 3 roller is required for fourth and fifth rolls of different sets for recurring periods of five minutes, viz., 10.20 to 10.25, 11.25 to 11.30, etc. In practice the rolls would be cut short or the leaf would have to be kept waiting for the roller. The use of the roll breaker is also badly arranged and if two were available they would probably be employed involving extra labour which could be saved by better organisation.

Diagram II.



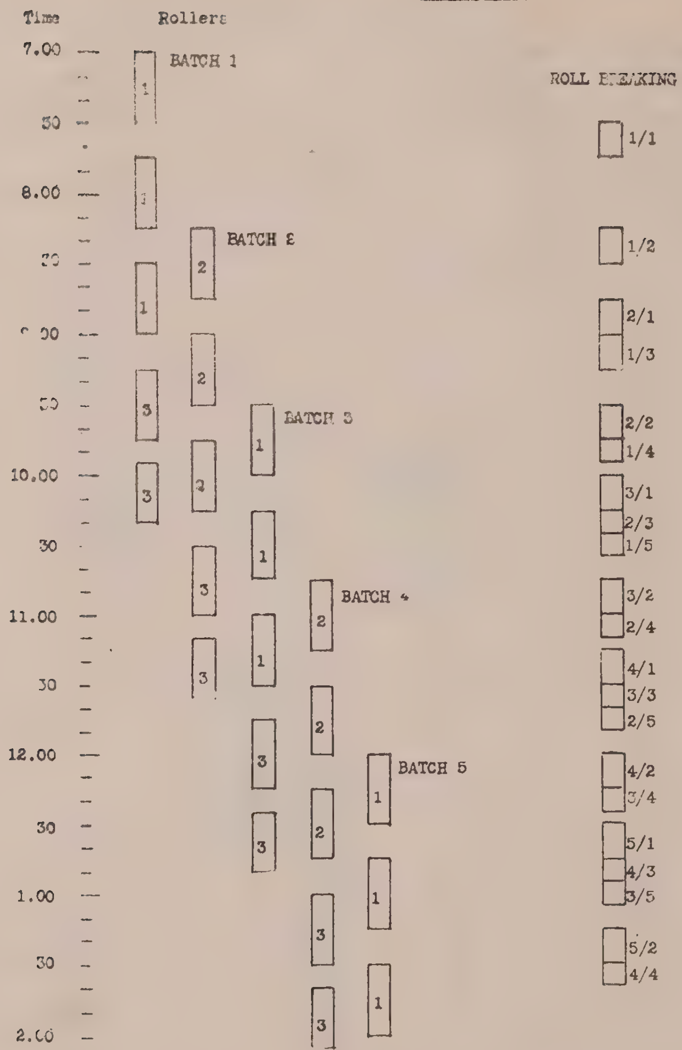
Details.

6 Roll programme for 3 rollers and 1 roll-breaker.
Charge — 580 lb.
Charging interval — 145 mins.
Out-turn rolled leaf — 3.8 lb. per min.

Comments.

This programme is well arranged, but charging two rollers and the consequently large charge gives the drier 145 minutes work assuming need of the same drier as in Diagram I which has a capacity of 3.8 lb. per minute. There is a very long interval between the first and last leaf fired and danger of over-fermentation of some dhools.

Diagram III.



Details.

5 Roll programme for 3 rollers and 1 roll-breaker.
Charge — 300 lb.
Charging interval — 75 mins.
Out-turn rolled leaf — 3.8 lb. per min.

Comments.

A well arranged programme using rollers and roll breaker with maximum efficiency. Fifteen minutes are allowed for roll breaking first and second rolls and 10 minutes for later rolls. The drier will fire the whole of each batch in 75 minutes.

45 minutes). This corresponds to 9.0 lbs. of leaf per minute being produced in the rolling room. Now if the drier can only deal with 8.0 lbs. per minute, fermented leaf begins to accumulate because each batch of leaf takes 50 minutes to fire whereas the rolling room is dealing with it in 45 minutes. Thus if it is decided to start firing at, say, 2 hours 30 minutes it will not be possible to start the second batch until 2.35, and by the time a sixth batch is fired the time becomes 3 hours. Such mistakes are common and are particularly liable to occur when there is a rush of leaf and the teamaker is anxious to speed up manufacture as much as possible.

The order in which rollers are used also requires careful planning, otherwise one roller may be required for say the fifth roll of the first set and the fourth roll of the second set, (see Diagram 1) with the result that one roll of leaf has to wait until a roller is ready or else it is combined with another batch of leaf. Unless programmes are carefully mapped out such pitfalls are abundant and indeed it is practically impossible to foresee snags unless the rolling programme is set out in the form of a diagram.

The first thing to do when planning a programme of manufacture is, therefore, to find the exact capacity of the firing machine at the temperature at which it is to be run. A firing machine should be run slightly under capacity, *i.e.*, spreading a little thinner than the maximum to allow a margin for adjustment when the wither is softer than usual or when a charge slightly larger than planned has to be used.

This capacity in pounds per minute is the capacity which the rolling room must work at and the rate at which withered leaf must be prepared for rolling.

The interval at which the rollers are to be charged must next be decided and this interval in minutes multiplied by the capacity (in pounds per minute) of the driers gives the charge for the rollers.

It is usually necessary to ponder over these figures for some time as there are several other things to be fitted in The rollers must be capable of dealing with the charge at the decided intervals and must be charged and discharged at specified times. Arrangements must also be made for roll breakers to be free when required. Diagrams 1, 2 and 3 illustrate these points. Normally it is desirable to charge at intervals of the order of sixty minutes or else the difference in time between the longest and shortest fermentation is too much and the later fired dhools become over-fermented. This interval is a matter for much experiment according to conditions, and some estates have found intervals as short as 40 minutes give good results.

The roll breaking intervals for the first rolls can usually be reckoned at 15 minutes and the later ones at 10 minutes but there again if roller charges are small shorter intervals may suffice. Further details are given in Mr. Whitehead's articles already quoted and these articles should be studied when planning programmes.

Without carefully planned organisation it is impossible to obtain consistent results or to apply with best effects the results of research on other aspects of manufacture. For instance, it has recently been proved that firing temperatures above 190°F. are injurious to quality. If a factory formerly employing an inlet temperature of 200°F. drops to 190°F, the capacity of the firing machine would be reduced with the result that unless the programme is modified fermentation times would increase owing to accumulation of fermented leaf and thus results, instead of improving, might easily deteriorate. Again, it is still not uncommon to find firing capacity greatly in excess of rolling room output. Here there is no danger of accumulation of fermented leaf and lengthening fermentation periods, but the drier runs empty between batches. In this case firing cannot be uniform since the leaf first passing through an empty drier is dried out much too rapidly and the bulk of the day's work is a mixture of leaf fired under a wide range of varying conditions. Gaps in firing programmes also mean waste of heat and high firing costs.

Organisation, even if it fails to bring about immediate improvement, enables new methods to be given a fair trial and when the best methods are found it enables the level of quality to be maintained. Apart from this, however, power, fuel and labour costs may often be reduced by attention to detail and choice of the most economic methods. For instance, three or four labourers may be employed on a roll breaker which can be dispensed with if the rolling programme is slightly altered (see Diagrams I and II) or, again, planned programmes may reduce the length of the working day and reduce overtime pay expenses.

The examples I have given all refer to small factories; the larger the factory the more vital becomes the question of organisation and, in general, large factories are much better organised than small ones. Once thorough organisation has been achieved all subsequent modifications are much simplified, record keeping is reduced to a minimum since there is no point in recording the same figures day by day, and the whole process of manufacture becomes infinitely easier to supervise.

Rolling appears to offer scope for considerable improvement and our experiments are now beginning to show promise of practical results. The experiments with the Clivemeare roller reported in

previous publications indicated that considerably improved liquors and infusions could be obtained by drastic methods applied over a comparatively short space of time and London blenders shewed great interest in the Clivemeare teas. Unfortunately, the Government contract specifications requiring grade percentages at the average figure for the previous three years, and the general state of uncertainty, ruled out a wider application of Clivemeare methods in general practice. From all but the blenders point of view, the appearance of Clivemeare teas was also too unorthodox to gain popularity in present circumstances. I feel certain that the Clivemeare roller, perhaps modified, will eventually establish itself but in the meantime it has undoubtedly opened up new lines of research.

The latest series of experiments has demonstrated the necessity for the employment of two different types of battens in normal rolling procedure, one for twisting without producing much dhool, and the other for cutting up the bulk when the twisting has been completed.

Cutting battens alone do not produce the best results, the reason being that the ordinary roller is too clumsy a contrivance to produce any effect on minute fractions of leaf of the size of ordinary dhools.

Upon the twisting action depends the satisfactory expression of juice and the rate and extent of fermentation. Unless leaf is thoroughly crushed, which is no easy task, unfermented tannin remains in the leaf when it is taken to the drier with resultant loss of strength and quality, and the formation of undesirable products when the fermented tannin is heated in the drier.

Our work on the biochemistry of tea is beginning to throw light on these processes and affords a useful guide to the solution of factory problems.

A number of commercial types of battens have been tested and information is now available to anyone interested. It is not desirable to publish comparative tests between battens marketed by different firms as each individual rolling problem should be considered on its merits. We have suggested, however, that commercial types should be offered as twisting or cutting battens and a distinction drawn between the various alternative centre battens usually available with each type. The reason for this latter caution is that we have found, by starting from a plain wooden table, that the greater part of the batten action takes place at the centre of the table and we have obtained 40 per cent of dhool in a single roll from a simple device screwed on the door of an otherwise plain table.

A shallow plain cone gave good results on a twisting table, but when two circular grooves were cut on the cone the table became a quite satisfactory cutting arrangement. The problems now being studied are how to get the maximum twisting action in the minimum of time and how quickly to reduce the bulk with cutting battens without making too much fannings, dust, and flaky leaf. Generally, it appears that the present tendency in general practice is towards over rolling. If a given type of batten has not achieved the desired result in two or three rolls it seems unlikely that it will do much better in four or five. Long rolling programmes mean a long interval between the first and the last dhools fired and the juice expressed in the first roll becomes over-fermented. (*Note* — This expressed juice is not necessarily in the first dhool — it may be in the Big Bulk).

Certainly the gradual expression of juice stage by stage is most undesirable because, once exposed to the air, fermentation of juice is a rapid process and part may get badly over-fermented with consequent dull liquors and infusions.

The whole idea of five and six rolls appears therefore to be a faulty one; the juice should be expressed as quickly as possible so that it will all ferment over the same period. High dhool percentages do not, however, mean complete expression of juice, the reverse is often the case. Leaf could be cut into small pieces with scissors without exposing but a small fraction of the total content of juice.

The main rolling problem in a nutshell is, therefore, to express juice completely and quickly without loss and without spoiling appearance and making too much dust, flaky leaf, and fannings. It offers much scope for ingenuity and is a problem which can be tackled on estates as well as at the Institute.

This may seem an obvious problem, nevertheless it has taken some considerable time to prove that these are the lines on which future work must concentrate.

In firing there has been an enormous improvement in the past few years. The improvement is not the result of any very fundamental changes in drier designs although drying machines have undoubtedly been improved, but is due to attention to detail. The Institute has a fair claim to some of the credit for these improvements. Firstly the moisture balance was introduced for the control of moisture content, then attention was drawn to exhaust temperatures as an index of firing conditions, while at the same time the closest co-operation with engineers has been maintained. Whereas six or seven years ago even new machines were frequently run badly

out of adjustment, very little interest being taken in technical adjustment so long as mechanical performance was satisfactory, drying engineers now carry sets of sensitive thermometers, anemometers, pressure gauges, CO_2 recorders and all the equipment necessary for fine adjustment and service. Consequently driers are adjusted to give even spread, air flow is even, output is satisfactory, thermometers are checked and fuel consumption is usually much reduced. Drying is becoming a precision operation and it is rarely that the Institute's officers discover serious faults in any but the very oldest machines.

Recently it has been proved conclusively that in a single firing operation, firing above 190°F. is injurious to quality, and that while firing at 160°F. produces teas of better quality when fresh, these teas are uncertain in keeping properties even when stored at low moisture contents. Whatever the inlet temperature the exhaust temperature must not be allowed to fall below 120°F. because below this temperature undesirable conditions are set up on the top row of trays. Similarly the exhaust temperature should never go above 135-140°F. A modern drier can be run between 125 and 130°F. without difficulty, and under these conditions will produce brisk teas for an economical consumption of fuel.

At the present moment work is in progress, and is nearing completion, on the question of the most suitable moisture content to which tea should be fired. The results of these experiments appear to be a foregone conclusion as 3-4 per cent has given consistently better results with both fresh and stored teas than 1-2 or 4-6 per cent.

These conclusions are drawn from the results of hundreds of experiments carried on throughout the various seasons and, although they have not indicated the necessity for any wide deviation from existing practices, they do define the best firing conditions and settle points which have been the subject of controversy.

Before completing this section on general manufacture, the results of the experiments on individual high-yielding bushes must be briefly mentioned. That individual bushes have been found to vary widely in the quality of the leaf they produce is an important fact and indicates the improvements in quality which may take place when clones are proved and vegetative propagation becomes a practical possibility, a hope which is quite likely to be realised.

2. FOREIGN MATTER

Whatever the rights and wrongs of the case are, the demand for hygienic methods of food manufacture is a very real one and,

furthermore, it is permanent and will become more insistent in the future. There has been a marked tendency in Ceylon to avoid the issue in this matter. Weighing up the impurities which have come to light in the form of complaints and expressing that weight as a percentage of total exports is useless. Even though this percentage may be an exceedingly small figure, the presence of *any* adventitious matter is greatly resented by buyers and brings the particular mark concerned into disrepute.

Each single impurity must be regarded as a potential complaint in which case an ounce of odds and ends, representing some minute percentage by weight, may represent fifty potential complaints.

Another excuse put forward is that impurities find their way into tea during bulking and blending and other operations subsequent to departure of the tea from the factory. This may be so, but it does not behove us to accuse other people until our own case is indisputable. I have even heard the whole question attributed to propaganda designed to sell machinery. It is no use trying to fool ourselves ; impurities can find their way into tea as they do into every other foodstuff and this is because of breakdowns or omissions in the hygiene of manufacture. I repeat that the public demand for hygienic methods in the manufacture of foodstuffs is a very real and insistent one and, even if only because "The customer is always right," we must conform to those demands. That the demand is strongest in America where we are trying to enlarge our markets, and where we shall have to sell in exchange for munitions of war is a fact which makes the matter even more important.

In recent years there has been a big development in hygienic methods of manufacture and the Tea Research Institute of Ceylon has taken the lead in the matter though, for obvious reasons, considerable restraint has been exercised in reference to this work in our publications. The subject has, however, been discussed in conference and at St. Coombs factory many devices to promote hygienic manufacture can be seen. We have also kept in close touch with engineering firms on this subject and there is really little excuse for lack of progress anywhere. A great deal of time, trouble and money has been spent in many factories all over the Island in improving hygienic conditions, and those who do not endeavour to keep up with the average are doing a great disservice to the tea industry of Ceylon which should not be permitted to continue.

So far as foreign matter is concerned, the essential part of hygienic manufacture is the elimination of the floor as a harbour for leaf once it has been sifted after withering. Although efforts may

be made to keep the floor clean it is the inevitable harbour of everything that falls, and mixing of leaf and foreign matter is almost unpreventable if the leaf is allowed to come in contact with it.

Fermentation, even when concrete is preferred as a surface, (and it has many advantages) must be carried out on raised platforms or tables and not on the floor as it is quite impossible to guarantee otherwise that the most carefully planned schemes will not allow the accidental inclusion of foreign matter.

Taken in order, the following points have all proved their worth:—

1. Withered leaf sifters.
2. Chutes with canvas extensions to allow withered leaf to be fed direct to the roller.
3. Designing or, in the case of existing machines, raising the rollers to allow of trolleys of ample capacity to receive discharged leaf.
4. Basins or Scoops for feeding leaf to roll breakers.
5. Design or, where possible with existing machines, adaptation of roll breakers to feed into trays or basins.
6. Raised fermentation tables or fermentation trays.
7. Trays for the reception of leaf discharged from the drier.
8. Rejection of all leaf falling on the floor.
9. Careful binding of boxes for storing dhools to prevent splinters of wood or nails, arising from wear or accidental damage, finding their way into the leaf. Trolleys should also be lined with sheet metal to exclude splinters. In the case of roller trolleys the door when allowed to fall unchecked often splinters the trolleys.
10. Raised platforms for picking over.
11. Magnetic cleaners and travelling inspection belts attached as feeding mechanism to packers.
12. Inspection of chests immediately before packing.
13. Uniforms for all factory labour and insistence on rules and regulations with regard to bangles and jewellery. The uniforms should have the minimum of pockets and the remaining pockets should be deep to prevent accidental loss of articles from them.

14. Adequate provision for washing or wiping feet or shoes at the entrance to factories and exclusion of all animals.

15. Regular inspection of brushes, and brooms and rejection of worn equipment. Prompt attention to wear in concrete areas.

16. Exclusion of all unauthorised persons from the factory.

Many other points will doubtless suggest themselves but most of the above have arisen in practice.

Hygiene is not merely a matter of reluctantly giving way to demands, for it has many advantages. Scrupulous cleanliness avoids dangers from taints and Benton in North East India has shewn that certain specialised bacteria which may proliferate in stale tea juice will give rise to products causing taints and initiate certain fermentation processes giving rise to dull infusions and soft liquors. The normal fermentation process is due to enzymes (ferments) contained in the leaf itself and fermentation caused by micro-organisms is unnecessary and so far as we know wholly undesirable.

We are carrying out experiments on these aspects of hygiene and, although it appears that dangers to quality from this cause are small in a normal hygienic up-country factory, there is evidence to suggest that sterilisation of machinery in low-country factories, by means of blow lamps at the commencement of each day's work, may have beneficial results. Whatever the elevation, however, taints will arise from lack of attention to hygiene.

3. TEA IN RELATION TO FOOD AND DRUG REGULATIONS

The necessity for Food and Drug Regulations is obvious, and the general public of most civilized countries are safeguarded by legal enactments. Such acts protect not only the consumer but the producers as well since wholesale adulteration is contrary to their interests

Tea adulteration was formerly a common practice in England, many leaves such as those of Plum, Poplar, Willow, Sloe, Elm, and others having been used fraudulently to increase the bulk of genuine tea. Thus in 1872, thirty-six out of forty-one tea samples in Birmingham were found to be adulterated.

The sale of Food and Drugs Act of 1875 although mainly repealed and replaced by such acts as the Food and Drugs (adulteration) Act of 1928 still stands in respect of those sections relating to tea.

In America acts "To prevent the importation of impure and unwholesome tea" date back to 1897 with amendments in 1908, and 1920. Canada, Australia, New Zealand, South Africa, Iraq are amongst other countries which have enactments regulating the importation and sale of tea.

In recent years the enforcement of these acts has been increasingly rigid and, although it is not necessary for the individual Planter to study these rules and regulations in detail, it is imperative that he should be aware of their existence and appreciate the necessity for ensuring that all Ceylon Teas exported from the Island conform to all Food and Drug Regulations.

Later investigations became necessary in regard to the occurrence of traces of lead in tea in excess of the limits imposed by the Food and Drug Regulations. A very thorough investigation of this question by the Tea Research Institute indicated that this was due mainly to the use of unprotected lead foil in packing or of lead coated machinery. The matter was easily put right and a subsequent analytical survery of Ceylon teas showed that such contamination had been, for all practical purposes, eliminated.

The object of regulations governing the sale of food and drugs are mainly:—

1. To prevent the consumer from injury to health.
2. To protect the consumer from fraud.
3. To protect the producer from unfair competition.

Injury to health may result from the use of poisonous facings, dyes and preservatives or from accidental inclusion of poisonous metals. Thus in 1923 difficulties arose from what was then a common practice, the facing of green tea with potassium ferrocyanide. This practice was stopped and is of academic interest only now since green tea is no longer made in Ceylon.

There has been a tendency when any complains of contamination or foreign matter have been received to attribute these to propaganda by rival traders in other beverages and stimulants. There is, however, not the slightest basis to support such an explanation. A brief appreciation of the general situation will show that not only tea but all beverages and stimulants are subject to examination by Public Health Authorities. The more frequent references now made to such regulations merely indicate the growing and very proper insistence on more rigorous standards of purity in all materials used as foods or beverages.

Fraud is now uncommon and adulteration by foreign leaves rare. Spent tea leaves may be re-dried and in some cases coated with gum or starch and rolled into small balls with sand and grit.

During the 1914-18 War a product called "Roka" was the subject of prosecutions. This was a compound of cereals, fruits and nuts rolled into small cylinders and used for adulteration up to 20 per cent. Lime or whitewash is sometimes added to increase colour or fine sand and grit to make up weight. Also shipments may be damaged by rain or sea water and subsequently re-dried.

Adulteration and fraud of this nature are detected by determination of ash contents and the percentages of soluble matter.

It occasionally happens that genuine tea may be questioned if accidental sand or grit raises the ash content to a suspicious level, or owing to some unusual growth conditions the ash content of genuine leaf is above or below the usual figures. Analytical investigations are carried out at the Tea Research Institute from time to time to discover the ranges of ash content, etc. in genuine tea. The elimination of fine sand from dust grades is of importance on this account.

Apart from these factors the inclusion, accidentally or otherwise, of any offensive foreign matter may involve legal proceedings.

For any of these complications to affect estates in Ceylon is very rare but every now and again events such as metallic contamination arise and it is necessary for such complaints to be fully understood. The final question to be reviewed is therefore the question of materials.

MATERIALS

War time conditions have raised a number of problems which may affect the aspects of quality concerned with Foreign Matter and Food and Drug Regulations unless the position is fully appreciated. Lead from lead coatings or metals containing even traces of lead very easily contaminate tea owing to the acidic nature of tea juice and the apparent affinity of tannin for lead. Stainless steel and aluminium have consequently been extensively employed in modern tea machinery, and immediately prior to the War materials such as monel metal were giving promising results from tests. The metals most suitable in tea manufacture are, unfortunately, those in great demand for munitions of war. Consequently we must expect, as replacements and repairs become necessary, to have to improvise and temporise until supplies of suitable materials are again available. Wood will fortunately meet all our needs for roller tables, and concrete (or glass) can be

used for fermenting tables. Roller jackets are a problem as stainless steel is the only material, so far employed, which is quite satisfactory. Where wood cannot be used brass will have to suffice but it should be limited to employment where stainless steel or wood cannot be obtained or applied and should be of high quality. Actually *pure* brass is a very satisfactory material but many of these alloys appear to contain lead originating as an impurity in the zinc. Chemical analyses can however decide any doubtful cases. Galvanised mesh will meet all our needs in roll breakers and green leaf sifters.

With regard to driers lead-coated trays are absolutely out of the question. Tin coated trays are very suitable but trays galvanised with *good* quality zinc are almost equally satisfactory. Galvanised ware may be employed to a limited extent *so long as it is of good quality*, but poor material, apart from any lead content, may contribute a small amount of zinc to leaf manufactured on it and this should not be allowed to proceed unchecked. Where stamped aluminium sheets cannot be obtained for sifting dry tea brass weave will suffice but it is most important that it should not be repaired with lead solder as this rapidly wears and causes marked contamination.

The question of linings is a difficult one. Lead is, however, quite satisfactory provided paper interleaving is used *between the lead and the tea* to protect the metal from abrasion. Experiments at the Tea Research Institute shewed that tissue paper interleaving eliminated lead contamination from this source.

Pure lead foil is not suitable for very long periods of storage as it tends to oxidize and form soluble compounds. Normally, lead foil is rolled out between sheets of tin and is thus tin coated.

Lacquers may find useful employment for coating metallic linings for tea and could be applied not only to lead but to zinc alloys. Certain zinc alloys of high tensile strength are now being offered for packing tea. Lacquers have solved many problems in the canning industry where the problems of metallic contamination of foodstuffs have been much more difficult than in the case of tea where the danger is only a limited one.

However much relaxation of Food and Drug Regulations there may be in war time, the requirements in regard to impurities which may pass into the infusion and thus prove injurious to consumers will stand. Tea must conform to these regulations and there is no difficulty about them which cannot easily be overcome.

Poisonous insecticidal sprays on tea in plucking are not used by the tea industry, so problems arising from this source do not affect us as they affect many, almost all, fruit industries.

Lastly, it should be pointed out that liability to metallic contamination and choice of materials are subjects in which the Tea Research Institute can give speedy and complete advice and this should be sought before any risk is taken.

SUMMARY

Tea Planting is becoming a complex subject and at the present moment subject to harassing difficulties. On this account it is hoped that a review of one aspect, namely manufacture, may prove helpful in providing a perspective and contributing to a sense of awareness of certain factors which may not have been studied in detail.

The wider implications of tea quality are discussed and a plea is made for endeavours to maintain some degree of progress with the idea of preventing deterioration in the general level of quality produced under war-time conditions.

It may be noted that the review deals with questions concerning all parts of the Island and indeed shews that by far the greater part of the Institute's research activities on quality concern the low-country as much as up-country. Thus, the sections of the review mentioning organisation, the principles of rolling, firing conditions, quality aspects of selection, hygiene, Food and Drug Regulations, and materials, affect low-country factories as much and in some cases more than their counterparts in Dimbula.

The review will also be of value if it gives some insight into the scope of the activities which have to be undertaken by a research organisation, such as the Tea Research Institute, responsible for all the technical problems arising out of a process of food manufacture, such as tea manufacture, under modern conditions.

MINUTES OF A MEETING OF THE BOARD OF THE TEA RESEARCH INSTITUTE OF CEYLON HELD 4-4-41

Minutes of a Meeting of the Board of the Tea Research Institute of Ceylon held at the Ceylon Chamber of Commerce Rooms, Colombo, on Friday, 4th April, 1941, at 2-30 p.m.

Present.—The Chairman (Mr. T. B. Panabokke, Adigar), the Financial Secretary (Hon'ble Mr. H. J. Huxham), the Chairman, Planters' Association of Ceylon (Mr. D. E. Hamilton), the Chairman, Ceylon Estates Proprietary Association (Mr. C. H. Bois), Messrs. J. D. Hoare, S. F. H. Perera, G. K. Newton, and Dr. R. V. Norris (Director and Secretary).

Mr. F. J. Whitehead was present by invitation.

1. The Notice calling the Meeting was read.

2. The Minutes of the meeting of the Board held on 19th December, 1940, were confirmed.

Letters expressing regret at inability to attend were tabled from the Director of Agriculture (Mr. E. Rodrigo), Major J. W. Oldfield, Messrs. R. G. Coombe and R. P. Gaddum.

3. MEMBERSHIP OF THE BOARD AND COMMITTEES

(i). The Chairman welcomed Mr. D. E. Hamilton on becoming an *Ex-officio* Member of the Board on his election to the Chair of the Planters' Association of Ceylon and congratulated him on his election.

He also welcomed Mr. G. K. Newton nominated by the Planters' Association of Ceylon to act for Mr. James Forbes on leave. (Letter dated 17th December, 1940, from Secretary, Planters' Association of Ceylon).

(ii). Reported that Mr. R. P. Gaddum had been nominated by the Ceylon Estates Proprietary Association to act for Mr. J. C.. Kelly proceeding on leave. (Authority letter dated 2nd April, 1941, from the Secretary, Ceylon Estates Proprietary Association).

(iii). The Chairman referred to the valuable help given by Mr. R. C. Scott, the late Chairman of the Planters' Association, both on the Board and the Finance Committee. A cordial vote of thanks to Mr. Scott for his services was recorded.

Finance Committee.—Proposed from the Chair that Mr. Gaddum be nominated to the Finance Committee to act for Mr. Kelly during his leave.—Approved.

Estate and Experimental Sub-Committee.—Reported that Mr. D. T. Richards had resumed his place on this Committee on his return from leave. Thanks to Mr. F. A. Bond for his services while acting for Mr. Richards were recorded.

The Chairman then said with the permission of the Board he would next take Item 5(d) in order not to detain Mr. Whitehead who had kindly attended to advise the Board on this matter.

5(D). EMPIRE DRIER AND REORGANISATION OF ST. COOMBS DRYING ROOM

The Chairman said details of the proposed scheme, which was concerned with alterations and repairs to the Empire Drier and the enlargement of the drying room to provide additional space for experimental work, had been given in the Minutes of the Estate and Experimental Committee which had been circulated to Members. The scheme was supported by this Committee and had been considered by the Finance Committee that morning.

The Finance Committee were in favour of the scheme in so far as technical and financial considerations were concerned. The only question was one of principle in regard to whether under present conditions the use of the required steel work was justifiable. The Committee referred this point for the opinion of the Board.

The Chairman asked the Financial Secretary for his view on this question.

Mr. Huxham said supplies of steel were very limited indeed and there would be great difficulty in obtaining further imports. He considered present stocks should be used with the greatest caution and envisaged possible Government control of this commodity.

Mr. Whitehead then gave details of the scheme. He stressed that immediate expenditure for the protection of the Empire drier were essential, and that if the scheme as a whole were not carried out much of this would be nullified and ultimately heavier expenditure would have to be incurred. He said more space was urgently required if the Institute was to have the means for adequate experimental work on machinery and plant. He stressed that the drying room was out of date and that St. Coombs factory should not be allowed to fall behind modern practice in its layout.

In regard to the question of steel work, Mr. Whitehead said in reconstructing the existing verandah and enlarging this, all existing steel work and roofing material would be used again and the amount of new steel work required was very small in amount and could all be supplied from existing stock in Ceylon, of which it would form but a negligible fraction.

Substantial annual and recurring savings would result from reduced insurance charges and lower upkeep charges, particularly in regard to chimney renewals.

Mr. Hamilton suggested that all steel uprights should be replaced by reinforced concrete pillars.

It was decided to adopt this modification and the Board after further discussion sanctioned a sum of Rs. 22,000 for putting into effect Mr. Whitehead's plan. This sum includes estate obligations.

In reply to Mr. Perera, the Director said the work of moving and re-erecting the driers would in each case be carried out by the Agents for the machine concerned.

The Chairman thanked Mr. Whitehead for attending and advising the Board, and Mr. Whitehead then left the meeting.

4. FINANCE

(A) AUDITED ACCOUNTS FOR 1940 AND AUDITORS' REPORTS THEREON

The Chairman referred to the satisfactory financial position as shown by the accounts for 1940 from which he quoted figures in regard to various items of receipt and expenditure. It was noted that the liability under depreciation reserve, now amounting to Rs. 399,362. was covered by cash and liquid assets to the extent of nearly 71 per cent.

In regard to the Estate Working Account, the profit at Rs 46,507 was the highest yet recorded for St. Coombs,

It was reported that 113,977 pounds of tea had been supplied to the Ministry of Food at an average price under the two contracts of 83.25 cents and 42,391 pounds sold on the local market at an average price of Rs. 1.01 gross.

The Audited Accounts were accepted.

Auditors' Reports.—The Chairman said these were of the usual satisfactory nature and there was little in them on which comment was required. The following matters had been considered by the Finance Committee.

(i). *Insurances.*—The Finance Committee were satisfied that insurance cover was adequate.

(ii). *Depreciation.*—The Board accepted the recommendation of the Finance Committee that the present practice should be continued whereby depreciation is not written off furniture, renewals being met from revenue account.

In regard to depreciation generally, the Financial Secretary suggested that at a later date the question of limiting provision against depreciation might be considered.

(iii). *Motor Roller and Motor Car.*—The Board approved the arrangements made by the Director in allocating depreciation on these two items.

(iv). It was agreed at the suggestion of Mr. Hoare that at the end of the present year the Director would present a statement showing the distribution of capital expenditure up to date as between the Estate and Research side.

(B) INSTITUTE'S ACCOUNTS FOR FEBRUARY, 1941

Reported that a further sum of Rs. 50,000 had been invested in Ceylon Government 2½ per cent War Loan.

The Accounts were accepted.

(C) INVESTIMENTS

The Director reported that the Attorney-General had ruled that the Institute could not place funds in the Interest free loan; it had also been found that the Institute could not purchase Ceylon Savings Certificates.

The Board confirmed the decision taken by circulation of papers to make the above investment of Rs. 50,000.

In regard to future investments, the Chairman said while there was an appreciable amount of cash in hand, receipts from the cess and tea sales would be slow in coming in during the first few months of the year. He thought therefore a fairly large sum should be kept free to finance current expenditure.

The Financial Secretary hoped the Board would not be too cautious in this respect and invest as much as possible of its funds in the War Loans.

After discussion, in which the question of advances from different banks against War Loans was considered, the Board asked the Chairman and Director to review the position at the end of each month so that any sum available, even if small in amount, might be invested at as early a date as possible.

(D) 1941 ESTIMATES

(i). Recorded that the amount voted in 1940 against capital expenditure for the Maternity Home and Lines and unexpended at the end of the year was Rs. 6,863. This sum was revoted under 1941 Accounts.

(ii). Estate Accounts. Vote 65, Engine Running Costs.—The Board approved the recommendation of the Finance Committee that the T. R. I. contribution to this vote be increased by 20 per cent in consequence of the increased cost of fuel and oil.

(iii). The Board sanctioned an additional vote of Rs. 180 under Research Estimates, vote 46, for replacement of the kitchen stove in the Director's bungalow.

(iv). Estimated Receipts.—It was noted that receipts under the cess were likely to be reduced by about Rs. 6,600 owing to restriction being increased to 10 per cent.

5. ST. COOMBS ESTATE

(a) *Visiting Agent's Report.*—Labour Out-turn.—An error in the report was corrected, the average out-turn being 76 per cent and not 68 per cent as recorded.

(b) *Disposal of St. Coombs Crop, 1941.*—Reported that 116,550 pounds had been accepted by the Tea Commissioner at an average price of 83.55 cents. The necessary agreement had been signed that morning. (Authority, Circular No. 6/41 of 5th March, 1941.)

(c) *Water Sanitation, St. Coombs Estate.*—The Board considered this scheme as detailed in the recommendation of the Estate and Experimental Committee. The Chairman reported that the Finance Committee had recommended that sanction should be accorded.

The Director gave details of the procedure to be adopted and the Board approved expenditure of:—

(i) Rs. 500 for increased water storage facilities.

(ii) Rs. 4,800 for providing water sanitation to the two new sets of lines, existing Nos. 1 and 2 lines and the factory latrine.

(d) *Use of St. Coombs Road by Kowlahena and Waltrim Estates.*—Reported that the agreement on the above matter had been duly signed. (Authority Circular No. A. 3/41 of the 3rd February).

6. MINUTES OF THE 46TH MEETING OF THE ESTATE AND EXPERIMENTAL COMMITTEE HELD ON THE 22ND MARCH, 1941

Most of the items had already been discussed under previous business.

The Director enlarged on the fertiliser position and stated that he had written to the Planters' Association of Ceylon and the Ceylon Estates Proprietary Association in regard to further rationing of Ammonium Sulphate and Nitrate of Soda. The position would be that :—

(i) Mineral Nitrogen would be restricted to one-third of the total nitrogen in tea mixtures.

(ii) Nitrogen in the form of Ammonium Sulphate would be limited to one-sixth of the total nitrogen.

The Director said in future larger supplies of groundnut cake would be required and he was making enquiries about the position from the Director of Agriculture, Madras.

In this connection, the Financial Secretary pointed out that there might be difficulties about freight from India and rates were being largely increased. The Director said he would maintain touch with the Fertiliser Firms on this subject.

In reply to Mr. Hoare, the Director said they had obtained no evidence to support the view that weed seeds were imported in groundnut cake.

The minutes of the Estate and Experimental Committee were recorded.

7. SENIOR SCIENTIFIC STAFF

(i). Reported that Mr. C. B. R. King had received a Commission as Pilot Officer in the R.A.F.V.R. (Administrative Branch) and left Ceylon on service in January.

(ii). Reported that Captain Tubbs had been promoted Major in January.

(iii). The Director conveyed Dr. Eden's thanks to the Board in connection with his promotion to the Selection Grade.

8. JUNIOR SCIENTIFIC STAFF

(i). *Small-Holdings Officer, Gampola.*—Reported that as a result of representations to the O.C., C.L.I., Mr. Illankoon was now being relieved for a period of two weeks every two months to attend to his civil duties.

(ii). *Small-Holdings Officer, Baddegama. Advance for car.*—The Board accepted the recommendation of the Finance Committee that an advance of Rs. 2,323 be sanctioned for the purchase of a car for official use.

9. TEA SCIENTIFIC CONFERENCE, S. INDIA

The Board approved the Director's suggestion that Dr. Gadd should be deputed to attend the Tea Scientific Conference to be held by the United Planters' Association of South India in August, 1941 and voted a sum of Rs. 500 for the expenses of this visit. It was noted Dr Gadd would at the same time visit the U.P.A.S.I. Tea Experimental Station and certain estates in S. India.

10. RECREATIONAL FACILITIES FOR SUBORDINATE STAFF

The Board sanctioned expenditure of Rs. 50 for the provision of a Volley Ball Court for the Subordinate Staff.

ROLAND V. NORRIS,
Secretary.

NOTICES.

The Institute's Laboratories and Offices are situated at St. Coombs, Talawakelle, and all applications and enquiries should be addressed to the Director, Tea Research Institute, St. Coombs, Talawakelle.

Specimens and other consignments sent by rail should be forwarded to Talawakelle Station c/o Messrs. M. Y. Hemachandra & Co., Forwarding Agents. *Carriage should be pre-paid.*

Visitors' Days.—The *second* and *last* Wednesdays in each month have been set aside as Visitors' Days at St. Coombs Estate, and also at the T. R. I. Sub-Station, Gonakelle Estate, Passara, when it is hoped anyone interested will visit the Stations.

Visitors at other times are welcomed, but it is requested that an appointment be made if possible.

RULES FOR THE OCCUPATION OF ST. COOMBS GUEST HOUSE

(1). The Guest House is normally intended for the use of persons visiting the Institute and St. Coombs Estate on business. Children can in no circumstances be accommodated.

(2). Permission to occupy a room for the night must be obtained from the Director in writing and, unless sufficient notice be given, accommodation cannot be guaranteed. Two double rooms are available for the use of visitors accompanied by their wives.

(3). All visitors must sign the Visitors' Book on arrival.

(4). A bedroom may not be occupied for more than one night if required by another visitor. This shall not apply to Members of the Board or of Committees meeting at St. Coombs who shall also be entitled to priority in the allocation of accommodation when on official business.

(5). Complaints or suggesstions shall be entered in the book provided for the purpose and not made to the Guest House Staff. All payments due for services rendered shall be made in *cash* to the steward-in-charge and a receipt obtained from him on the official form. The scale of approved charges is posted in the building. The steward is forbidden to give credit or to accept cheques.

(6). Liquor is supplied for consumption *in the premises only.*

(7). The Institute accepts no responsibility for cash, jewellery or other valuables of any kind left in the Guest House.

(8). All breakages will be charged for at cost price.

ROLAND V. NORRIS,
Director.

The Tea Research Institute of Ceylon.

BOARD OF CONTROL

(A) Representing the Planters' Association of Ceylon:—

(1) Mr. R. G. Coombe

(2) Mr. James Forbes (on leave), Mr. G. K. Newton (acting).

(3) Mr. J. D. Hoare

(B) Representing the Ceylon Estates Proprietary Association:—

(4) Major J. W. Oldfield, C.M.G., O.B.E., M.C.

(5) Mr. I. L. Cameron (on leave) Mr. W. H. Gourlay (acting)

(6) Mr. J. C. Kelly (on leave) Mr. R. P. Gaddum (acting)

(C) Representing the Low-Country Products' Association:—

(7) Mr. S. F. H. Perera

(D) Representing the Small-Holders:—

(8) Mr. T. B. Panabokke, First Adigar (Chairman)

(E) Ex-Officio Members:—

(9) The Hon. the Financial Secretary

(10) The Director of Agriculture

(11) The Chairman, Planters' Association of Ceylon

(12) The Chairman, Ceylon Estates Proprietary Association

Secretary, Roland V. Norris, D.Sc., St. Coombs, Talawakelle.

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The publications of the Tea Research Institute will be sent, free of charge, to Superintendents of Ceylon tea estates, over 10 acres in extent, and to Estate Agencies dealing with Ceylon tea, if they register their names and addresses with *the Director, Tea Research Institute of Ceylon, St. Coombs, Talawakelle.*

Other persons can obtain the publications of the Institute on application to the Director, the subscription being Rupees fifteen per annum for persons resident in Ceylon or India, and £1-5-0 for those resident elsewhere. Single numbers of *The Tea Quarterly* can be obtained for Rs. 2-50 or 4*s*. In the case of Indian cheques four annas should be added to cover commission.